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CHEMICAL CLEANING SOLVENTS: BOILER DESCALING WITH TETRA-AMMONIUM ETHYLENE-DIAMINE TETRA-ACETIC ACID

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CHEMICAL CLEANING SOLVENTS BOILER DESCALING WITH TETRA-AMMONIUM ETHYLENE-DIAMINE TETRA-ACETIC ACID

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NAVSECPHILADIV RDT&E Project A-1385
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The tetra·ammonium salt of ethylene·diamine tetra·acetic acid is an effective agent for removing scale from naval boilers. The cleaning procedure effects significant savings in cleaning time and post-cleaning boiler readiness operations. However, the release of toxic ammonia gas into confined machinery spaces as a result of leakage and the corrosive effects upon alloys such as Monel and 2¼-1 chrome-molybdenum steel present serious doubts as to its employment for cleaning naval boilers.

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SUMMARY PAGE

The Problem

This project was initiated to determine whether various salts of ethylene-diamine tetra-acetic acid (EDTA) could be used to remove waterside deposits from naval boilers.

Findings

Based on an actual shipboard evaluation on the forward pair of boilers of the USS HARRY E. YARNELL (DLG-17), the tetra-ammonium salt of EDTA was found to be an effective agent for removing scale from naval boilers. Five-thousands inch hard scale, present on tube samples taken prior to the cleaning operation, was completely removed as evidenced by actual inspection of the boilers and examination of adjacent tube samples removed after the cleaning. Boilers cleaned by this method do not require replacement of hand-hole gaskets nor post-cleaning wire-brushing as compared to conventional acid cleaning methods. However, serious problems can occur with the release of ammonia gas into confined spaces when leaks develop and with corrosive attack upon alloys such as Monel and $2\frac{1}{4}$-1 chrome molybdenum steel. Such deficiencies might be remedied by using other salts of EDTA for chemical cleaning.

Recommendations

It is recommended that tetra-ammonium EDTA not be used for cleaning naval boilers.

It is further recommended that other salts of EDTA be evaluated as cleaning agents for naval boilers.

ADMINISTRATIVE INFORMATION

Authority for this project was granted under the Naval Ship Systems Command Work Request WR-2 5428, Amendment No. 2 of 3 Sep 1971. Costs for conducting the investigation were chargeable to Appropriation/Subhead 1721804.2475. The Navy Index Number S 4638, Task 11604, Dart Number 1.3.16.

REPORT OF INVESTIGATION

INTRODUCTION

Various salts of ethylene.diamine tetra.acetic acid (EDTA) show promise as chemical cleaning agents for the removal of operational deposits from naval boilers. Dow Chemical Company, a leader in the chemical cleaning field and a manufacturer of EDTA salts, was consulted for recommendations concerning the use of EDTA to remove this type of deposit. They recommended Vertan 675, the tetra.ammonium salt of EDTA as the best agent for this purpose, citing several successful cleaning operations with utility boilers over the past ten years.

Coincidental to this inquiry, tetra.sodium EDTA was being evaluated as a boiler water treatment chemical in the aft fireroom (2A, 2B boilers) of the USS HARRY E. YARNELL (DLG-17). A recent comparison between sample tubes taken from both the conventionally treated forward boilers (1A, 1B) and the Na_4 EDTA treated aft boilers revealed hard deposits of 0.005 inch thickness in the forward boilers. Accordingly, it was recommended to the Type Commander that boilers 1A and 1B be chemically cleaned. NAVSECPHILADIV offered technical direction for the use of Vertan 675 by Dow Industrial Services to accomplish the cleaning.

EVALUATION PROCEDURES AND RESULTS

The contractor submitted a proposal which included the use of an estimated 2500 pounds of Vertan 675 for each of two boilers. The unit operations and times required to perform the cleaning were outlined in sequential steps forecasting an estimated completion period of 16 to 29 hours. The actual cleaning operation was performed over a period of three consecutive twelve hour days.

Prior to the cleaning operations, NAVSECPHILADIV installed metal test coupons in each water drum to assess the corrosive effect of the Vertan 675 on various metal alloys. Boiler preparation by NAVSECPHILADIV and a sub-contractor consisted of the following actions.

1. Installation of rubber plugs in the steam line to blank off the superheaters.
2. Installation of steam drum vent connections to carry off ammonia fumes from the fireroom.
3. Installation of stainless steel coolers and temporary piping from the surface blow connections to provide for sampling during the operations.
4. Installation of temporary piping with check valve to the bottom blow line for the air-blowing phase of the operation.

The procedure required that the boilers be lit off and brought up to 150 psi before the first step of injecting the inhibitor could be

accomplished. Protection steam was provided for the superheaters throughout the cleaning operation. Extreme weather conditions(8°F) created difficulties with the contractor's pumping equipment and most of the first day was spent piping up from pier to fireroom and in making pump repairs. The operation was halted for the day after the inhibitor had been injected into the boilers.

The following day the boilers, being at approximately 40 psi, were treated with about 300 gallons each of Vertan 675. The boilers were then fired tc a pressure of 150 psi before securing and allowing to cool. The normal procedure is to fire and secure the boiler between 50 and 150 psi until the concentration of Vertan 675 levels off. Shortly after the fires were secured on 1B boiler, gross leakage occurred and,as a result, the cleaning solution flooded the bilge. This caused the fireroom to be saturated with ammonia fumes. The cleaning of 1B boiler was terminated. It was later determined that nine RI and RJ main generating bank tubes had failed at the water drum. It was estimated that the cleaning solution had been present in 1B boiler for four hours from injection time to mid-drainage time.

The cleaning of 1A boiler proceeded according to plan with the leveling off of the Vertan concentration at the end of the second day. The boiler was allowed to cool overnight. The air-blowing phase, to remove copper, was begun on the third day. This phase of the operation calls for a

temperature of less than 180 F and is normally achieved by allowing the boiler to cool down overnight. When the required solution emf is attained through instrumental measurement, the air-blowing is secured and the solution drained from the boiler by air pressure. The unit was then filled once with 180 F rinse water, drained and opened for inspection.

Inspection of two inch tube samples RA-16, 1A boiler and RA-12, 1B boiler following the cleaning operation showed minimal loose soft deposits. The previous five thousandths hard scale had been completely removed. Inspection of drums and headers showed a few scattered soft deposits remaining. The RI and RJ tubes of 1B boiler which had leaked during the cleaning showed defects at highly stressed areas at the water drum. Fourteen tubes required plugging in addition to the four tubes which had been plugged prior to the cleaning operation.

Examination of the corrosion specimens indicated that 2¼-1 chrome-molybdenum steel coupons in 1A and 1B boilers and the Monel coupon in 1A boiler had been attacked by the cleaning solution. It appears that the air-blowing copper removal phase is very detrimental to Monel metal. The corrosion specimen test results are as follows:

TABLE I

Corrosion Rates (lbs/sq ft/hr)

Alloy	Boiler 1A	Boiler 1B
Monel 400	0.0024	0.0001
Stainless Steel (18-8)	0.0000	0.0000
16-1 Croloy Steel	0.0000	0.0001
2¼-1 Cr Moly Steel	0.0046	0.0044
Carbon Steel	0.0005	0.0017

Samples were taken from the steam drum of 1A boiler throughout the cleaning procedure. Chemical analysis for various metals was performed by NAVSECPHILADIV using atomic absorption. The results are as follows:

TABLE II

Metal Concentrations (ppm)

Sample	Iron	Copper	Nickel	Zinc	Magnesium	Calcium
1/9-1230	10,500	2	100	174	133	226
1330	12,000	5	100	212	135	230
1415	16,500	7	102	212	147	230
1530	18,500	2	84	204	53	142
1720	20,000	2	84	192	60	202
1810	19,500	16	84	174	42	88
1/10-1400	13,000	76	68	136	72	102
1430	16,500	203	84	154	89	168
1515	16,500	360	84	154	95	180
DUMP	16,500	360	84	152	90	194

DISCUSSION

The examination of sample tubes removed from both boilers following the cleaning showed that tetra-ammonium EDTA is an effective agent for removal of scale from boiler watersides. Considerable savings in time and manpower are obtained. The boiler is filled only once with cleaning solution, hand-hole gaskets do not need replacing after cleaning, the tubes do not require wire-brushing afterwards to remove loose deposits and disposal of spent cleaning solution is easier due to smaller volumes and milder chemical effects compared to mineral acids. Nevertheless, this method of cleaning does present serious problems which cannot be overlooked. A listing of these deficiencies would include the following:

1. Any cleaning method which requires firing the boiler, automatically introduces the possibility of a low-water tube casualty if gross leakage occurs.

2. Any cleaning method which generates a pressure of 150 psi tends to magnify and increase any leakage.

3. The use of the tetra-ammonium salt of EDTA introduces irritating and dangerous ammonia fumes into confined working spaces.

4. The corrosion test specimen results, although consisting of only one panel of each alloy in each boiler, show that Monel and 2¼-1 chrome-moly steel are heavily attacked by the cleaning solution.

CONCLUSIONS

It is concluded that:

a. The tetra-ammonium salt of EDTA should not be used in the chemical cleaning of naval boilers because of inherent safety deficiencies related to the production of ammonia gas and because of the corrosive attack on alloys such as Monel and chrome-molybdenum steel.

b. The mixed results derived from the evaluation of the tetra-ammonium salt of EDTA dictate that further work with other EDTA salts must be accomplished.

RECOMMENDATIONS

It is recommended that tetra-ammonium EDTA not be used for cleaning naval boilers.

It is further recommended that other salts of EDTA be evaluated as cleaning agents for scale removal from naval boilers.

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